Chapter 2
An Exploration of Backpropagation Numerical Algorithms in Modeling US Exchange Rates

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ABSTRACT

This chapter applies the Backpropagation Neural Network (BPNN) trained with different numerical algorithms and technical analysis indicators as inputs to forecast daily US/Canada, US/Euro, US/Japan, US/Korea, US/Swiss, and US/UK exchange rate future price. The training algorithms are the Fletcher-Reeves, Polak-Ribiére, Powell-Beale, quasi-Newton (Broyden-Fletcher-Goldfarb-Shanno, BFGS), and the Levenberg-Marquardt (LM). The standard Auto Regressive Moving Average (ARMA) process is adopted as a reference model for comparison. The performance of each BPNN and ARMA process is measured by computing the Mean Absolute Error (MAE), Mean Absolute Deviation (MAD), and Mean of Squared Errors (MSE). The simulation results reveal that the LM algorithm is the best performer and show strong evidence of the superiority of the BPNN over ARMA process. In sum, because of the simplicity and effectiveness of the approach, it could be implemented for real business application problems to predict US currency exchange rate future price.

1. INTRODUCTION

Currency exchange rate forecasting is crucial for financial institutions to estimate currency risk, increase profits, and to monitor strategic financial planning. Additionally, active participants in the foreign exchange market such as traders, investors, and speculators continuously make arbitrage and hedging transactions so as to affect financial institutions wealth and national economies. Consequently, all these participants become dependent on the response in the foreign exchange market. Nowadays, governments, economists and participants in the foreign exchange market are increasingly interested in models that

allow accurately predicting currency exchange rate. However, currency markets are generally perceived as nonlinear and no stationary systems which are difficult to predict (Majhi et al, 2012).

Statistical models such as the auto regressive moving average (ARMA) (Box et al, 1994) and generalized autoregressive conditional heteroskedasticity (GARCH) (Bollerslev, 1986) models and linear regression methods were largely applied by researchers and scholars in modeling foreign currency exchange rates (Hsieh, 1989; Liu et al, 1994; Brooks, 1996). However, all these linear statistical models require a priori assumptions about the underlying laws governing the data and the model specification. As a result, their applications are restricted to linear specifications of the model. They are also restricted to stationarity and normality distribution of variables and errors. Indeed, these assumptions are not true in real life situations, which lead to poor prediction quality (Hu et al, 1999; Yao & Tan, 2000).

In the last decade, soft computing tools such as multilayer artificial neural networks (ANN) (Rumelhart et al, 1986; Haykin, 2008) were introduced in currency exchange time series forecasting (Hu et al, 1999; Yao & Tan, 2000) since they do not make such assumptions. In addition, they are adaptive and robust to noisy and incomplete data. Furthermore, the ANN employs the traditional empirical risk minimization principle to minimize the error on training data using the backpropagation algorithm. Finally they were proven to be effective and accurate in different time series application problems; including electrical load (Kulkarni, 2013), stock market volatility (Wei, 2013), river flow (Singh & Deo, 2007), car fuel consumption (Wu & Liu, 2012), flood (Feng & Lu, 2010), and rainfall-runoff forecasting (Sedki et al, 2009), in stock market prediction (Lahmiri, 2014; Lahmiri et al, 2014a, 2014b), and also recently in currency exchange rate forecasting (Majhi et al, 2012; Sedki et al, 2009; Majhi et al, 2009; Panda & Narasimhan, 2007; Sermpinis & Laws, 2012; Hussain et al, 2006; Dunis et al, 2011).

For instance, Majhi et al, (2012) used functional link artificial neural network (FLANN) and cascaded functional link artificial neural network (CFLANN) to predict currency exchange rate between US/British Pound, US/Indian Rupees, and US/Japanese Yen. The computer simulation results showed that each neural network outperformed the standard least mean square (LMS) algorithm. In addition, the CFLANN offers superior prediction performance in all cases in comparison with the FLANN. In their study, Majhi et al, (2006) employed Wilcoxon artificial neural network (WANN) and Wilcoxon functional link artificial neural network (WFLANN) to reduce dependency of the network weights to the outliers in the training data. Both networks were found to be robust in the prediction of US/Indian Rupees, US/British Pound, and US/Japanese. In addition, it was found that WFLANN offers low computational complexity and hence preferable as a robust prediction model for currency exchange rates than WANN. Panda and Narasimhan (2007) found that the neural network has superior in-sample forecast than linear autoregressive and random walk models in the prediction of the weekly Indian rupee/US dollar exchange rate. In addition, the neural network was also found to beat both linear autoregressive and random walk models in out-of-sample forecasting. Anastasakis and Mort (2009) applied both neural networks with active neurons and self-organizing modeling methods for the daily prediction of the US/British Pound and the Deutche/British Pound. They found that both networks are capable to outperform the random walk model and the buy-and-hold strategy. Sermpinis et al, (2012) compared the performance of the Psi sigma neural network (PSI), the gene expression algorithm (GEP), multi-layer perceptron (MLP), recurrent neural network (RNN), genetic programming algorithm (GP), ARMA process, and naïve strategy when applied to the task of modeling and forecasting the EURO/USD exchange rate. They found that the PSI network performs the best. In addition, all models outperformed the ARMA process and naïve strategy. In similar studies, the PSI presented satisfactory results in forecasting the EUR/USD, the EUR/GBP and the EUR/JPY exchange rates having as benchmarks a HONN model (Hussain et al, 2006). On

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